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NASA's Space Science Enterprise

Origins, Evolution, and Destiny of the Cosmos and Life

We humans are players in the greatest drama of all, the story of cosmic Origins, Evolution, and Destiny. Now, for the first time, we are beginning to truly understand our role, as we grasp the opportunity to seek scientific answers to questions as old as humanity itself:

How did the universe begin?
How did life on Earth arise?
What fate awaits our planet and our species?

We have begun to assemble answers to these grand questions using remarkable new tools on Earth and in space. But, more importantly, our understanding is growing through the intellect and imagination of men and women who look up and wonder, who devise new means of gathering information that lead to the formulation and testing of theories to explain what it all means. This is a Golden Age of discovery as exciting and significant as the time when humans turned their first telescopes to the heavens.

In the past few years, we have seen faint folds in the fabric of the universe, the most ancient ancestors of all the galaxies, stars, and planets that surround us. We have used telescopes on the ground and in space to discover disks of gas and dust surrounding young stars— nurseries of potential worlds—and to discern evidence for giant planets orbiting nearby stars. We have found living creatures in extreme environments previously not thought capable of sustaining life— the dark depths of Earth's oceans and the dry valleys of the Antarctic. We have studied meteorites from Mars, one of which shows clear evidence of the presence of ancient water and the chemical building blocks of life, and—possibly— tiny, fossilized microbes. Our spacecraft have returned images of what may be ice floes above a liquid water ocean on Jupiter's moon Europa, and made us wonder if life may begin on moons as well as planets. We have seen a comet collide with Jupiter and studied a supernova from first explosion to expanding gas cloud. We have learned that Earth's climate, biosphere, and the workings of our entire technological civilization are profoundly influenced by the behavior of our varying Sun, a star we can study close-up. We have detected giant black holes that may be as massive as a billion suns at the center of our Galaxy and in other galaxies, turning centuries of theory into fact. We have seen bursts of gamma rays from distant reaches of space and time, momentarily more powerful than a million galaxies. Our understanding of the universe has been altered forever.

We have learned much, but many questions remain to be answered. How could an ordered universe emerge from a formless beginning? Is life in our solar system unique to Earth, or might there be evidence of past or present life on other moons and planets? Can we forecast space weather by better understanding the forces that drive our Sun? In so doing, can we better protect our astronauts and the orbiting satellites on which our global communications depend? Can we develop the scientific base of information necessary to save Earth from an incoming asteroid like the one we believe ended the epoch of the dinosaurs 65 million years ago? Will a "Big Crunch" follow the Big Bang, billions of years from now, or will our universe expand endlessly?

A Stellar Record of Discovery

In 1999, research projects sponsored by the Office of Space Science as well as information returned from its spacecraft, resulted in numerous major discoveries. The reach of Space Science study ranges from relatively nearby bodies such as the Moon, asteroids and Mars, to our Sun, to the giant outer planets and their moons, to the center and outer reaches of our own Milky Way Galaxy and reaching out to almost unimaginable distances of space and time almost to the very beginnings of the universe. Among the most important discoveries in 1999:

- The Hubble Space Telescope Key Project Team announced they found a value for how fast the universe is expanding after eight years of painstaking measurement.

The rate of expansion, a value called the Hubble Constant, is essential to determining the age and size of the universe.

- Astronomers funded by NASA have witnessed for the first time a distant planet passing in front of its star, providing direct and independent confirmation of the existence of extrasolar planets that to date have been inferred only from the wobble of their star. Also, using a method called "microlensing," astronomers have found evidence of the first known planet orbiting a pair of stars. Previously, planets have been found circling only single stars.

- NASA's Mars Global Surveyor (MGS) returned a wealth of amazing images and major discoveries at Mars. MGS found evidence for ancient crustal movement on Mars, and provided the first global 3-D map of the Red Planet. The map gives scientists their first detailed understanding of the relative heights of various geologic features on the Red Planet, including regions that shaped the flow of water early in Mars' history and what may be the largest impact basin in the Solar System. MGS images also show that Mars is a different place today than it was two years ago when the spacecraft arrived—a world constantly reshaped by forces of nature including shifting sand dunes, monster dust devils, windstorms, frosts and polar ice caps that grow and retreat with the seasons.

- Astronomers racing the clock managed to take the first-ever optical images of one of the most powerful explosions in the universe—a gamma ray burst—as it was occurring on January 23, 1999. Gamma ray bursts produce more energy in a very short period than the rest of the entire universe combined.

- The Chandra X-Ray Observatory, launched into space aboard the Space Shuttle in July, almost immediately began returning the best-ever X-ray images of a variety of cosmic objects, including a major discovery of a ring around Crab Nebula.

- The Deep Space 1 launch and mission achieved all its advanced technology objectives, including ion drive and autonomous navigation.

- Using the Japanese Yohkoh spacecraft, NASA-sponsored scientists have discovered that an S-shaped structure often appears on the Sun in advance of a violent eruption, called a coronal mass ejection, that is as powerful as billions of nuclear explosions. Early warnings of approaching solar storms could prove useful to power companies, the communications industry and organizations that operate spacecraft.

- Solving a long-standing solar mystery, scientists have discovered the source of fountains of electrified gas that flow from the Sun like water gushing through cracks in a dam. Called the high-speed solar wind, this gas flows out at two million miles per hour from the edges of honeycomb-shaped patterns of magnetic fields at the surface of the Sun.

- Galileo detected hydrogen peroxide and sulfuric acid on the surface of Europa. Sulfuric acid—a corrosive chemical found on Earth in car batteries—exists on the frozen surface of Jupiter's icy moon Europa.

- The high-speed portion of the solar wind achieves its unexpectedly high velocity—up to 500 miles per second—by "surfing" magnetic waves in the Sun's outer atmosphere, according to observations made by two spacecraft during John Glenn's return to space (SOHO & Spartan).

- A dramatic time-lapse movie by Hubble shows for the first time seasonal changes on the massive and remote planet Uranus: massive storms, each one could stretch from Kansas to New York, with temperatures of 300 degrees below zero.

- In a virtually perfect repair and maintenance mission, the crew of the Space Shuttle *Discovery* replaced Hubble's gyros, made numerous improvements to battery power and guidance systems, and gave it new outer layers of thermal protection, making it better than new. The Hubble was released into space on Christmas Day 1999 and soon returned to scientific operations.

Future of Space Science

Over the next several years and decades, NASA missions will complete the initial survey of the Solar System with the flyby of Pluto; continue exploration of the major outer planets with the Cassini mission at Saturn; return samples of comets, asteroids, and Mars to Earth for laboratory study; and launch telescopes much more powerful and larger than Hubble, yet at a fraction of the cost, which will study everything from the most violent objects in the Universe to possible Earth-like planets around nearby stars

The four long-term goals of the Space Science Enterprise are:

- Establish a virtual presence throughout the solar system, and probe deeper into the mysteries of the Universe and life on Earth and beyond—a goal focused on the fundamental science we will pursue

- Pursue space science programs that enable, and are enabled by, future human exploration beyond low-Earth orbit—a goal exploiting the synergy with the human exploration of space

- Develop and utilize revolutionary technologies for missions impossible in prior decades—a goal recognizing the enabling character of technology

- Contribute measurably to achieving the science, mathematics, and technology education goals of our Nation, and share widely the excitement and inspiration of our missions and discoveries—a goal reflecting our commitment to education and public outreach

To better study solar variability and understand its effects on humanity, NASA is starting a program called "Living With A Star," a set of missions and enhancements to current programs which will eventually encompass a number of spacecraft and systems. Living With A Star will undertake the most comprehensive scientific study of the Sun and its interaction with Earth to date. It will study in great detail the entire 11-year Solar Cycle to give us an unprecedented understanding of its variable and often violent nature and the effects it can have on Earth. In much the same way that we have to study Earth's weather patterns repeatedly throughout all four seasons, we can only obtain the level of detail and scientific understanding of the Sun's effects that we seek by studying the Sun's entire cycle. Living With A Star also will pursue partnerships with other Federal agencies which are concerned with the effects of the Sun on Earth. The goal is to provide an exciting new capability for understanding, and ultimately predicting, "solar weather" which affects Earth.

In the decade ahead the Office of Space Science will be developing missions to gain new answers to the fundamental questions posed by the cosmos. There will be twists and turns along the way, unexpected discoveries that will show us that the universe is not quite the way we thought. And there will almost certainly be difficulties. Developing new tools to extend the frontiers of the known is always challenging.

At the beginning of the new millennium, NASA's Space Science Enterprise is building on decades of spectacular achievements and is poised to provide a much better understanding of the formation and evolution of the universe, how the Sun influences Earth, the history of planets and satellites in our solar system, and the occurrence of life either in our tiny region of space or in the larger neighborhood of our Galaxy. NASA's Office of Space Science is at the forefront of humanity's quest to probe the mysteries of the Cosmos and understand our place in it.

More information about NASA's Office of Space Science is available on the World Wide Web at:

http://spacescience.nasa.gov

At this site you will find information including a message from Associate Administrator Dr. Edward Weiler, the Enterprise Strategic Plan, a comprehensive listing of missions, research opportunities and announcements, news about recent discoveries, advisory committees, and numerous links to a galaxy of information resources.